

# Requirement Development Process and Tools

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# Objective: Develop System Requirements Document

- Capture the system-level capabilities in a set of complete, necessary, clear, attainable, traceable, and verifiable statements of need (Requirements)
  - Should not be unduly restrictive<sup>1</sup>
  - Sets limits that eliminate items outside the boundaries drawn
  - Encourage competition (or alternatives)
  - Capture source and reason of requirement

**If it is not needed by the customer, it is not a requirement**

- Establish the verification methods that will lead to product acceptance
  - These must be reproducible assessment methods

**The SRD sets the standards by which the Product will be evaluated**

# System Qualification and Requirements Verification

Component Design

Component Qualification

System Qualification

Design and Construction Standards And Constraints

Comp. Ready for Qual

SMC-S-016 or Alternate

	Valve or Propulsion Component	Pressure Vessel or Component
Inspection <sup>(1)</sup>	R	R
Specification Performance <sup>(1)</sup>	R	R
Leakage	R	R
Shock	ER	ER
Vibration or Acoustic <sup>(2)</sup>	R	R
Acceleration	-	ER
Thermal C	ER	ER
Thermal V	R	R
Climatic	ER	ER
Pressure	R	R
EMC <sup>(4)</sup>	ER	ER
Life	R	ER
Burst Press	R	R
Static Load	-	ER

Show you can survive/operate in an environment

Evaluate Component Performance

- Flow Vs.  $\Delta P$
- Frequency Response
- Dynamics
- Power Draw

Subsystem Tests

Test	Multi-Unit Module
Inspection	R
Specification Performance <sup>(1)</sup>	R
Static Load	R
Pressure	ER
Shock	ER
Random Vibration or Acoustic	ER
Thermal Vacuum	R
Separation and Deployment	ER
EMC	ER
Mode Survey	ER

Evaluate Integrated Performance

Vehicle Tests

Test	Space Vehicle
Inspection	R
Specification Performance <sup>(1)</sup>	R
Pressure/Leakage	R
EMC <sup>(2)</sup>	R
Shock	R
Acoustic or Random Vibration <sup>(3)</sup>	R
Thermal Balance	R
Thermal Vacuum	R
Mode Survey	R

System Req't Verification

Analysis is the predominant means for closing system-level Requirements

Component Designed and Built properly

Component Model Validation

NASA-STD-7009 or Alternate Verification

System Model Validation

May be rolled into vehicle testing

Critical Functions Verified for Hazard Reports

Evaluates all primary and redundant systems

Vehicle Model Validation

# Importance of Process Discipline and Supporting Tools in Requirements Development

- SRR ensures the requirements and concept satisfy the mission.
- Requirements Validation builds the case as to “why” each requirement is levied. Ensures:
  - Necessity
  - Traceability
- Requirements Maturation ensures:
  - Achievability
  - Clarity
  - Verifiability
- Requirement Owners
  - Drive the development of requirements and validation products
  - Maintain the corporate knowledge of decisions that lead to those products
  - Represent their discipline in providing requirement oversight (compliance and verification) throughout the life cycle.

RO's synthesize the needs of stakeholders and develops a balanced set of requirements trading needs and affordability

# Choose the Tool to Support Your Process

“Scope, constraints, operational concepts, interface details, verification assessments, requirement, and review notes, you may feel like you are smothered in lists before your team finishes the first iteration of requirement definitions....The process must be repeated for every requirement level in the product’s development.”

- Ivy Hooks, Customer-Centered Products

“Begin with the end in mind”

- Stephen Covey, 7 Habits of Highly Effective People

- Requirements Development, Maturation, Configuration Management, and Risk are best supported through implementation of a database
  - Central Repository to which multiple organizations can contribute
  - Provides framework for expounding upon the data typically found in the Req Doc
  - Maintain relationships amongst data that live in different domains
  - Allow varying views into the data to support different work plans

# Requirements Development

- At SRR we want to understand why each of these requirements has been levied
- Requirements must be traced to other products to justify their existence
  - Functional Architecture, OPSCON, Parent Requirements, Station IRD
  - Database allows different views into these relationships; hides complexity in the final document
  - Uncovers gaps when looked at as sets of requirements

	LSC.13.1 : Execute Plane Change	LSC.13.2 : Free Flight Operations	LSC.13.3 : Prep for DOI	LSC.13.4 : Perform DOI	LSC.13.5 : Perform Lunar Descent	LSC.13.6 : Perform Powered Descent	LSC.13.7 : Perform Post Landing Checkout
LNDR.1.2 : Deliver Flight Crew Equipment/Pressurized Cargo	LCAP.120.1: Equipment Stowed						
LNDR.1.3 : Transport Crew	LCAP.130.2 Crew Inhabited						
LNDR.1.3.1 : Provide Crew Ingress/Egress from Orion	LCAP.131.1: Docking Hatch Closed						
LNDR.1.3.2 : Provide Crew Ingress/Egress to Lunar Surface and Ground	LCAP.132.1: Surface Hatch Closed						
LNDR.1.4 : Return Cargo	LCAP.140.1 Return Cargo UnStowed						
LNDR.1.5 : Transport EVA Suits	LCAP.150.1: EVA Config 2 Suits Donned						
	LCAP.151.1: PLSSs Stowed						
LNDR.1.6 : Transport Orion into LDO	LCAP.160.1: Orion unattached						
LNDR.2.1 : Provide exterior viewing	LCAP.210.2: Exterior Viewing for Landing Ops Available						Exterior Viewing for Landing Ops Unavailable
	LCAP.211.2: Exterior Viewing for Docking Ops Available						Exterior Viewing for Docking Ops Unavailable
	LCAP.212.1: Exterior Viewing for EVA Ops Unavailable						Exterior Viewing for EVA Ops Available
LNDR.2.2 : Control Lighting	LCAP.220.2: Read + Panel Lighting On						
LNDR.2.4 : Provide Waste Management	LCAP.240.1: Waste Collection System Stowed						
	LCAP.241.2: EVA Suit-provided Waste Mgmt Available						
LNDR.2.5 : Provide Galley Service							
LNDR.3.1.1 : Inertial Navigation							
LNDR.3.1.2 : Orion-Relative Navigation							
LNDR.3.1.3 : Terrain Hazard Navigation							
LNDR.3.1.5 : Attitude Determination							
LNDR.3.2 : Perform Translational Maneuvers							
LNDR.3.3 : Perform Attitude Control							
LNDR.3.4 : Perform Guidance							

## 3.8.4.4 Windows for Crew Tasks

The spacecraft shall provide windows that are available for use by the crew through all phases of flight that provide direct, non-electronic, through-the-hull viewing and the unobstructed fields-of-view necessary to perform crew viewing tasks.

Ground  
update Active

Terrain  
navigation off

Attitude  
Update off

AM Main  
DM Main  
afed

DM RCS

Attitude

Trajectory

(Guidance Off)

# Role of Requirement Owners

- Single Owners of the groups of requirements manage them as a set to:
  - Reveal omissions
  - Prevent loss of requirements by stakeholders
  - Capitalize on a broad experience base
- Secondary benefits
  - Single POC for reconcile disparate comments from various stakeholders by a deadline
  - Develop a broader verification strategy for the discipline
  - Reconcile with other requirement books and standards
  - Drive resolution of TBXs
  - Ensure common terminology across discipline

# Process Automation: Tool Selection

- Divide and Conquer – A central repository allows multiple users to log-in and maintain their own set.
- Shift focus from document mgmt to content mgmt
- Configuration Management – Database tools have rich baselining capabilities
  - Allows Requirements to mature independently
  - Manage TBD's more effectively
- Implementation – Database allows us to create cross references to lower level specs
  - Queries can report whether all the requirements have been matched
  - Reports can assess the sufficiency of the matched requirements to meet the totality of the parent.



# Requirement Risk Tracking

- Requirements Risk Identification

- Assess each requirement for:

- Criticality - Impact on the design
    - Achievability - Potential for meeting the requirement through normal development
    - Criticality

- Purpose is to provide priority on addressing requirement deficiencies

- C1 - Requirement is a Key Driving Requirement, an MOE, the Requirement Describes Functionality that costs >3% dry mass, or directly drives LOC (to first order)
    - C2 - the Requirement Describes Functionality that costs 1-3% dry mass or directly drives LOM (to first order), or represents substantial cost investment or schedule implication
    - C3 - Requirement Describes Functionality that costs <1% dry mass

- Achievability Assessment



- r – Low Likelihood of Compliance (<50% chance)
  - y – Medium Likelihood of Compliance (50-80% chance)
  - g – High Likelihood of Compliance (>80% chance)
  - grey - Unassessed

A	C	D
ID	Name	Requirement Text
REAB137	Altair Vestibule Pressurization Cycles	Altair shall provide not less than two vestibule pressurization cycles per mission for Lunar Sortie and Lunar Outpost crew missions.
REAB139	Altair Fire Detection and Suppression	Altair shall provide fire detection and suppression for the Altair pressurized volume for Lunar Sortie and Lunar Outpost crew missions.
REAB141	Lunar Surface Location	The Constellation Architecture shall determine stationary element location anywhere on the lunar surface to within (TBD-001-068) m ((TBD-001-068) ft) with 95% probability.
REAB144	Altair navigation and attitude determination	Altair shall perform navigation and attitude determination beginning with Earth orbital operations through Altair disposal.
REAB145	Altair Lunar Descent	Altair shall compute maneuvers associated with lunar descent and landing beginning with DOI.
		Altair shall provide a habitable environment for a crew of four for a

Assessments are dashboard of performance

# Implementation Risks

- Process and tools requires support
  - Facilitated by SE&I
- Systems requires training
  - Insight Teams/Mgmt
  - Reqmnt Owners/Developers
  - Database Admins
- System on the Critical Path
  - Development dependent upon system availability
  - Mitigated by enterprise solutions that share burden across projects

# Summary

- Utilizing Requirement Owners and a database to facilitate Requirements Engineering and Requirements Management increases requirement quality and uncertainty throughout the lifecycle
- Rationale:
  - Integrates Requirements Development and statusing into a common framework
  - Maintains detailed history of requirement evolution
  - Allows cross-references more elaborate datasets
  - Establishes clear ownership and coordination channels